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COMMUNITY NOISE SOURCES
AND NOISE CONTROL ISSUES

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COMMUNITY NOISE SOURCES AND NOISE **CONTROL ISSUES**

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NOISE COMPONENTS TBE TURBOJET

Unsuppressed levels for the Turbine Bypass Turbojet Engine (TBE) at each of the certification points indicates the suppression needed to achieve FAR 36 Stage 3. At sideline 20 EPNdB jet noise suppression is needed, at cutback 16 EPNdB jet noise and 2 EPNdB burner noise, at approach 6 EPNdB jet noise, 7 EPNdB burner noise and 10 EPNdB suppression of turbine noise.

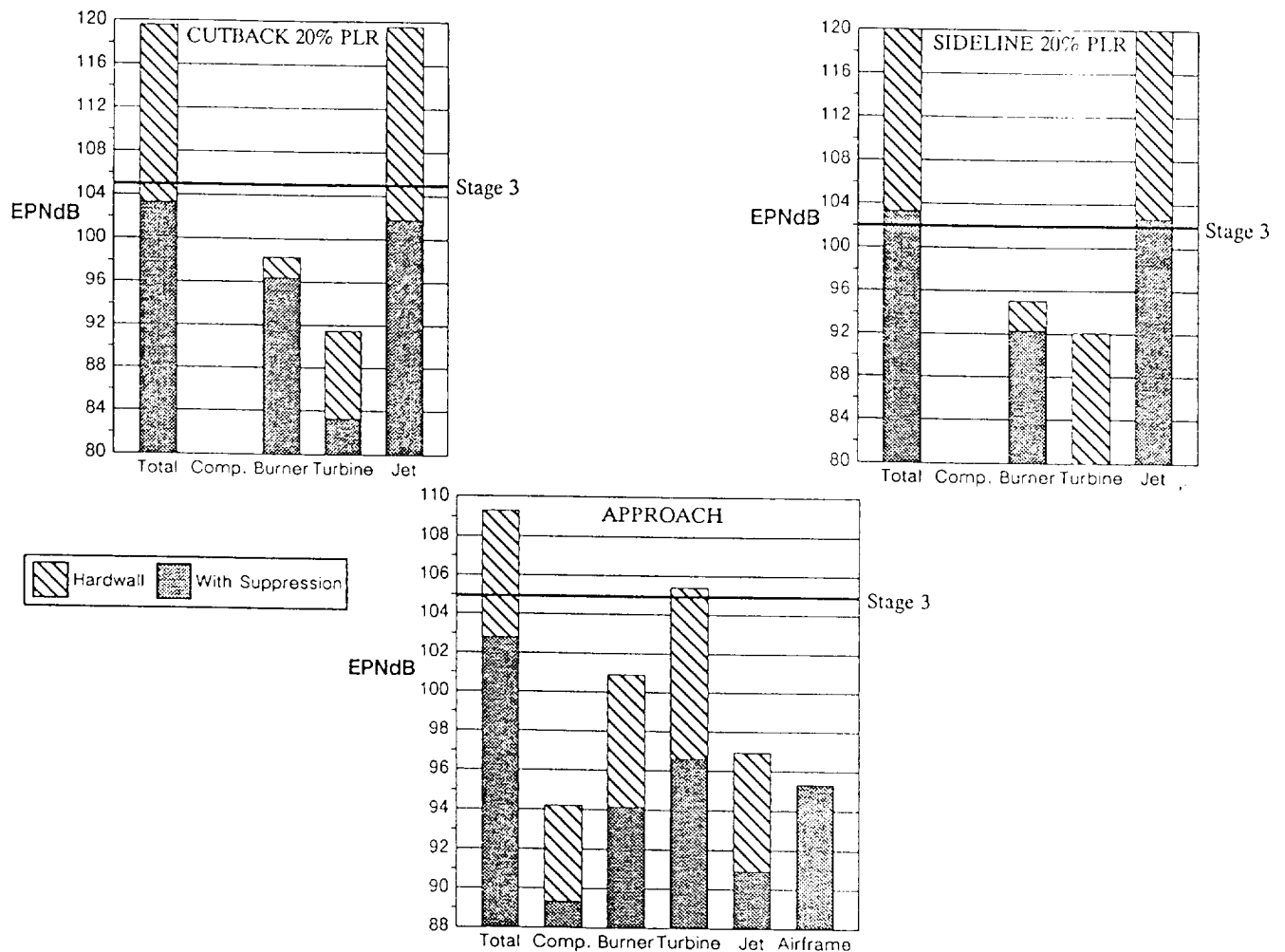


Figure 1 Noise Components Turbine Bypass Turbojet Engine

ENGINE CYCLE SELECTION AND NOISE

The engine cycle selection will determine the jet noise suppression required from 20 EPNdB for the turbojet to less than 10 EPNdB for some of the low specific thrust variable cycle engines. Understanding of nozzle technology to achieve 20 EPNdB suppression is needed to understand the engine cycle / jet suppression trades.

Variable Cycle Engine Developments

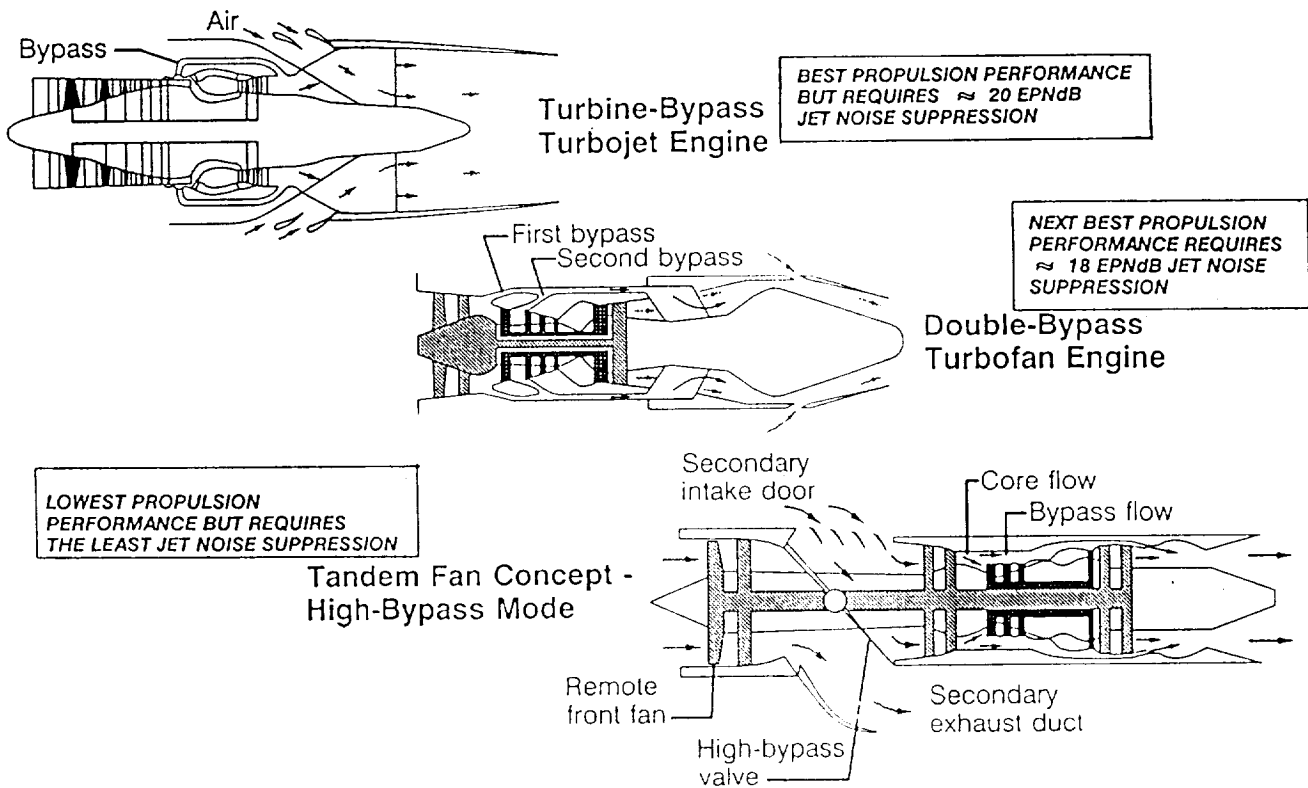


FIGURE 2

NOZZLE DEVELOPMENT SCHEDULE

Model scale nozzle development testing will continue through 1995 followed by verification testing using a large scale demonstrator engine. Tests in 1991 include elements of the nearly fully mixed (NFM) nozzle, a variable geometry version of the NFM nozzle and source diagnostics of the NFM nozzle. Source diagnostics will include cross-correlation of far field noise with internal velocity fluctuations.

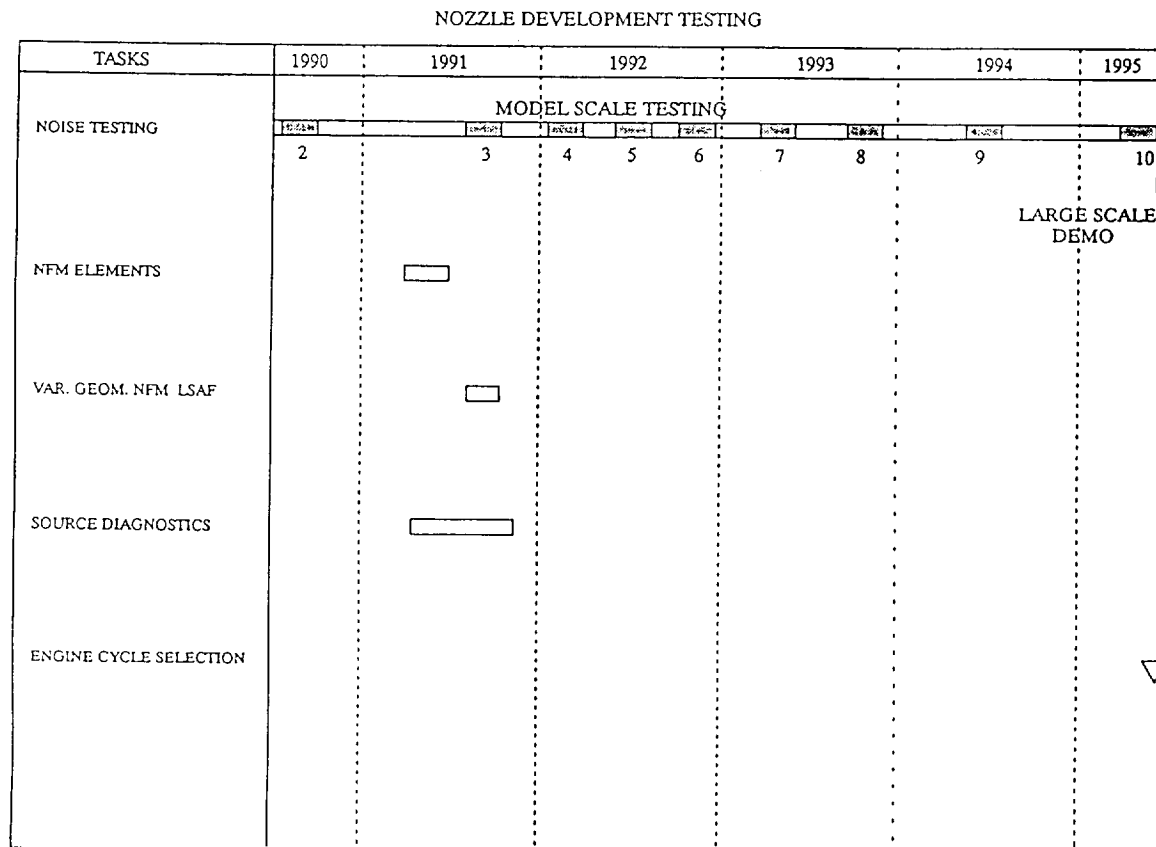
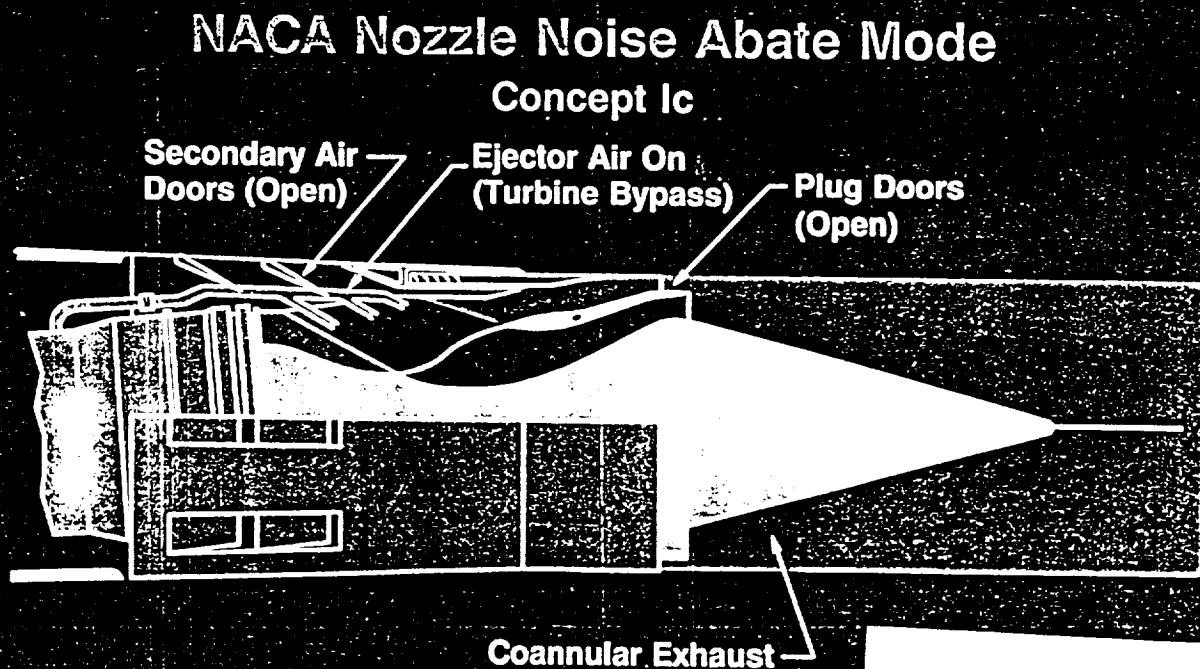


FIGURE 3

NACA NOZZLE DESIGN

A jet suppression test was completed on the Naturally Aspirated Co-Annular (NACA) nozzle in 1989. The original design NACA nozzle aspirated 40% of the core flow. This was increased to over 60% by using the turbine bypass air as a second ejector. The core flow crosses over the aspirated flow into an annulus. This produces an inverted velocity profile as a noise reduction feature. A large external plug was used in addition.

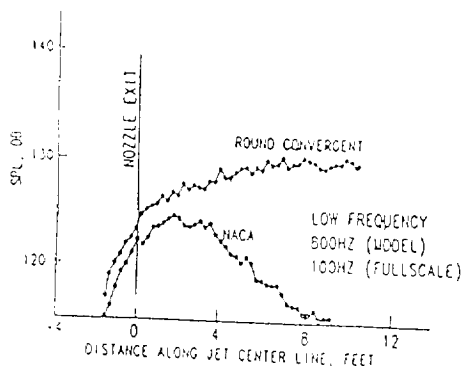
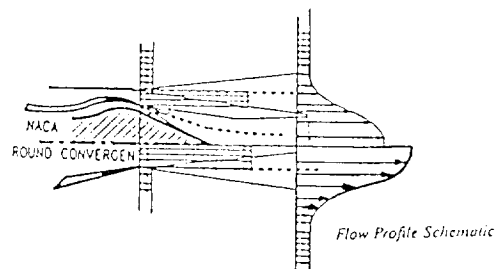


BOEING
PROPRIETARY

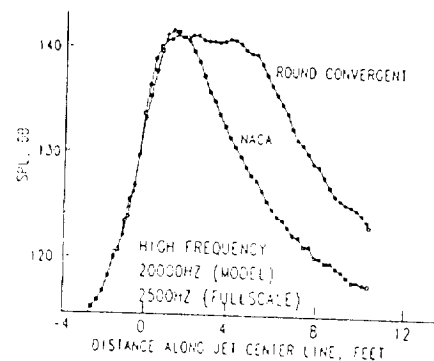
NACA NOZZLE TEST RESULTS

The mixing of the aspirated flow and the primary jet takes place outside of the nozzle so that the primary stream is at full velocity in the initial mixing region. This results in large noise reduction down stream but no reduction of high frequency noise generated in the initial mixing region limiting the suppression to 10 EPNdB.

NATURALLY ASPIRATING CO-ANNULAR, NACA, NOZZLE SOURCE LOCATION



Elliptic Mirror Noise Source Distribution Scan at a Low Frequency



Elliptic Mirror Noise Source Distribution Scan at a High Frequency

FIGURE 5

NFM NOZZLE DESIGN

One solution to the NACA nozzle limitation is to mix the aspirated flow inside a treated ejector and Boeings version of this nozzle is called the Nearly Fully Mixed (NFM) nozzle. This nozzle aspirates 100+ % of the core flow, fully mixes the core and aspirated flows inside the ejector and minimizes internal shock cell noise from the primary nozzle. The internally generated mixing and shock cell noise is reduced with acoustic lining. The internally generated mixing and shock cell noise is reduced with acoustic lining.

Internally Mixed Ejector - Suppressor Nozzle Concept

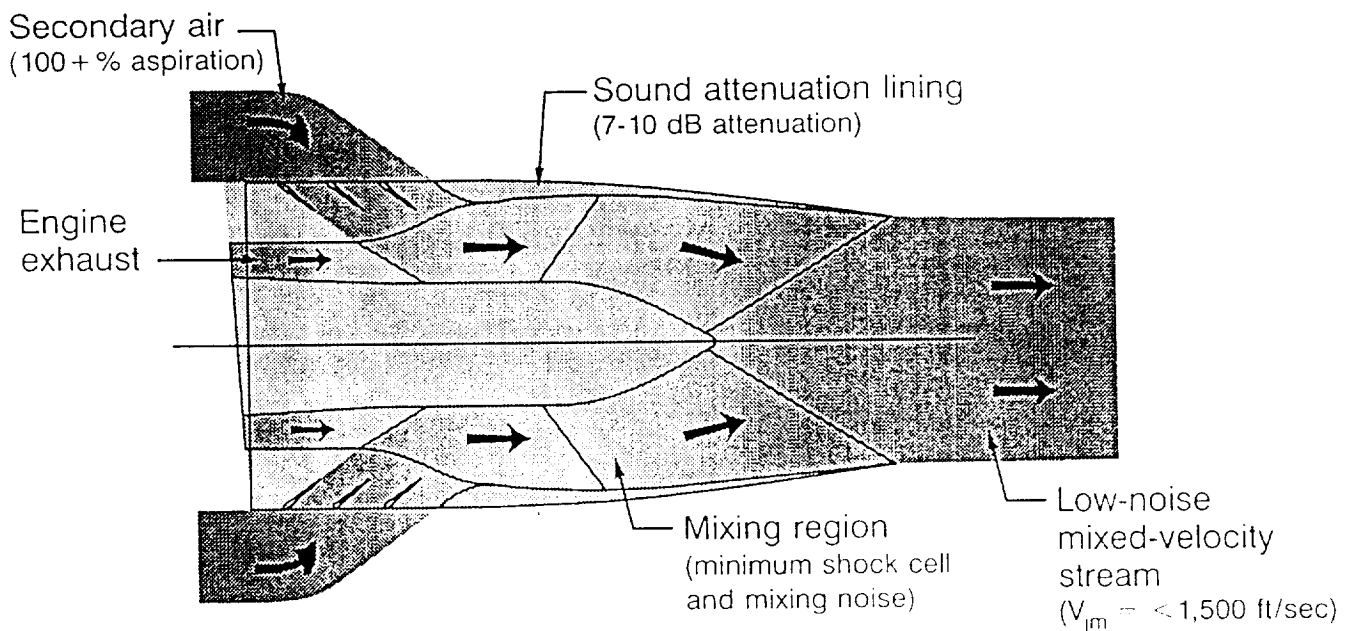


FIGURE 6

NOISE VERSUS ASPIRATION RATE

Noise reduction of an aspirating nozzle has the potential of reducing noise to the level of an equivalent nozzle with the fully mixed stream flow conditions. The noise reduction potential of an aspirating nozzle versus aspiration rate is shown. NACA nozzle and NFM nozzle data are also shown. Neither nozzle reaches its full potential, the NACA nozzle because the streams are mixed outside the nozzle and the NFM nozzle because some internally generated noise is still radiated out.

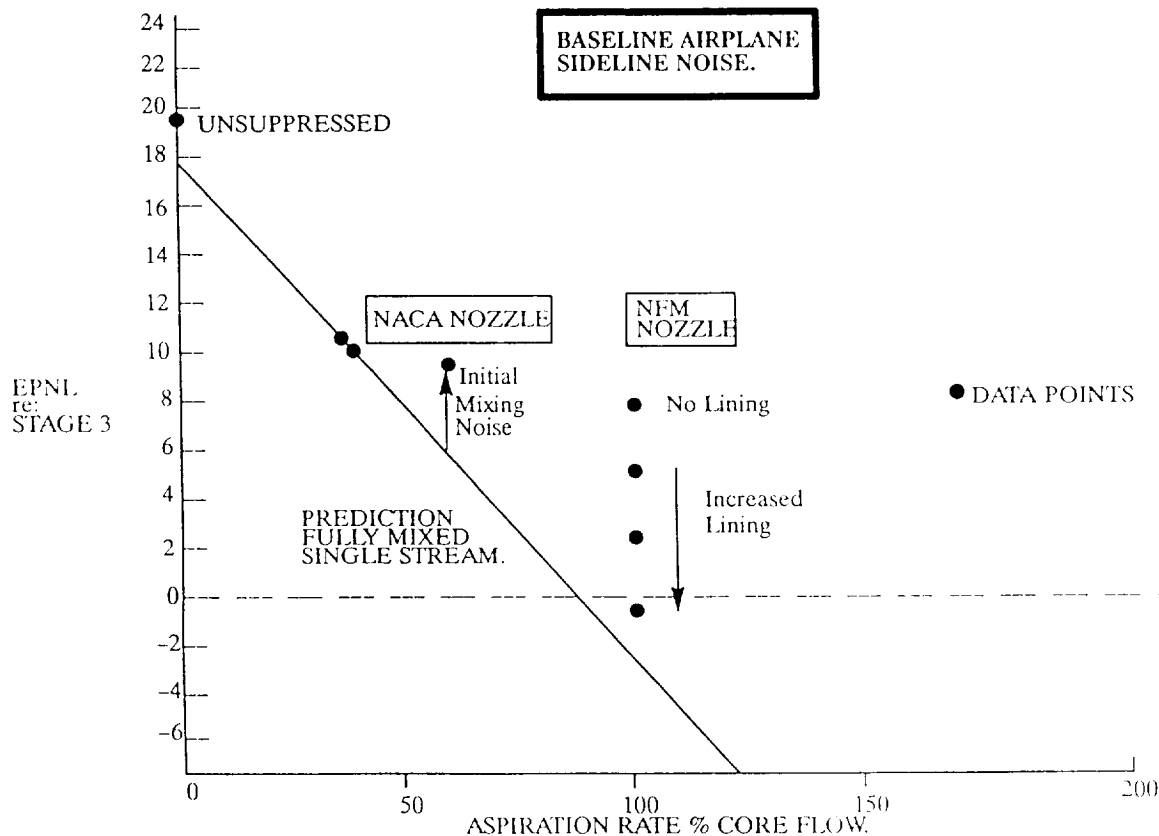


FIGURE 7

PEAK NOISE TEST RESULTS

The reference RC nozzle noise spectrum is shown at its peak radiation angle (140°) compared to the NACA and NFM nozzles at their peak angles (110°). The high frequency noise reduction of the NACA nozzle is limited because the mixing takes place outside the nozzle. The NFM nozzle, with the longest treated ejector, shows large noise reductions at all frequencies.

NFM, NACA, and RC Nozzle Noise Comparison

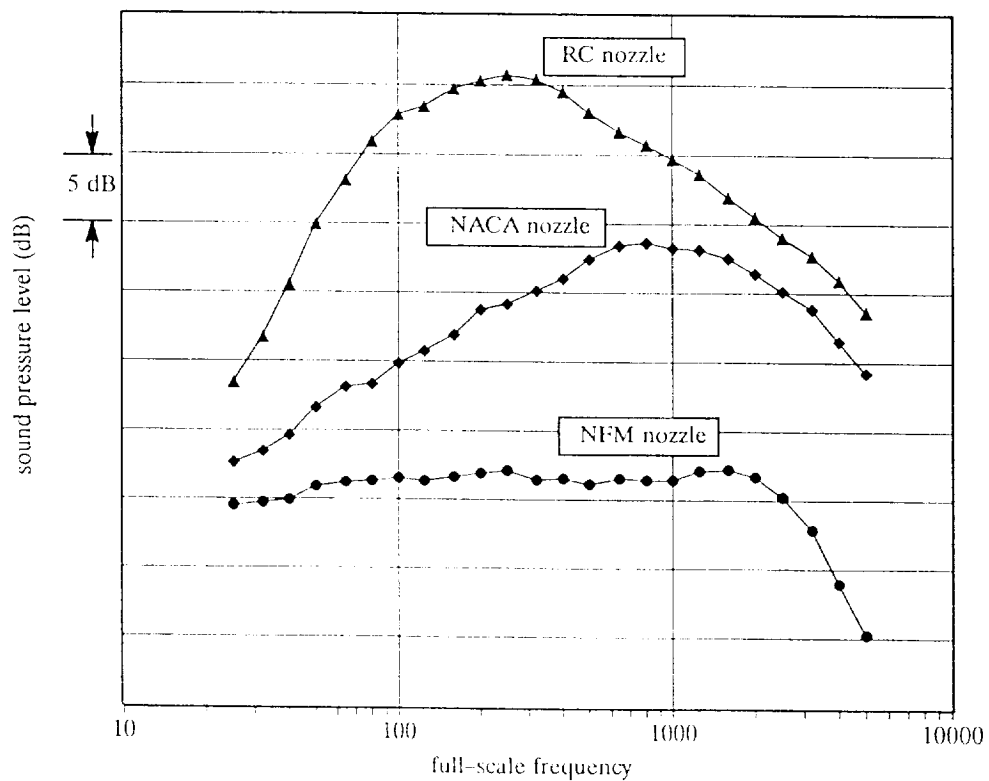


FIGURE 8

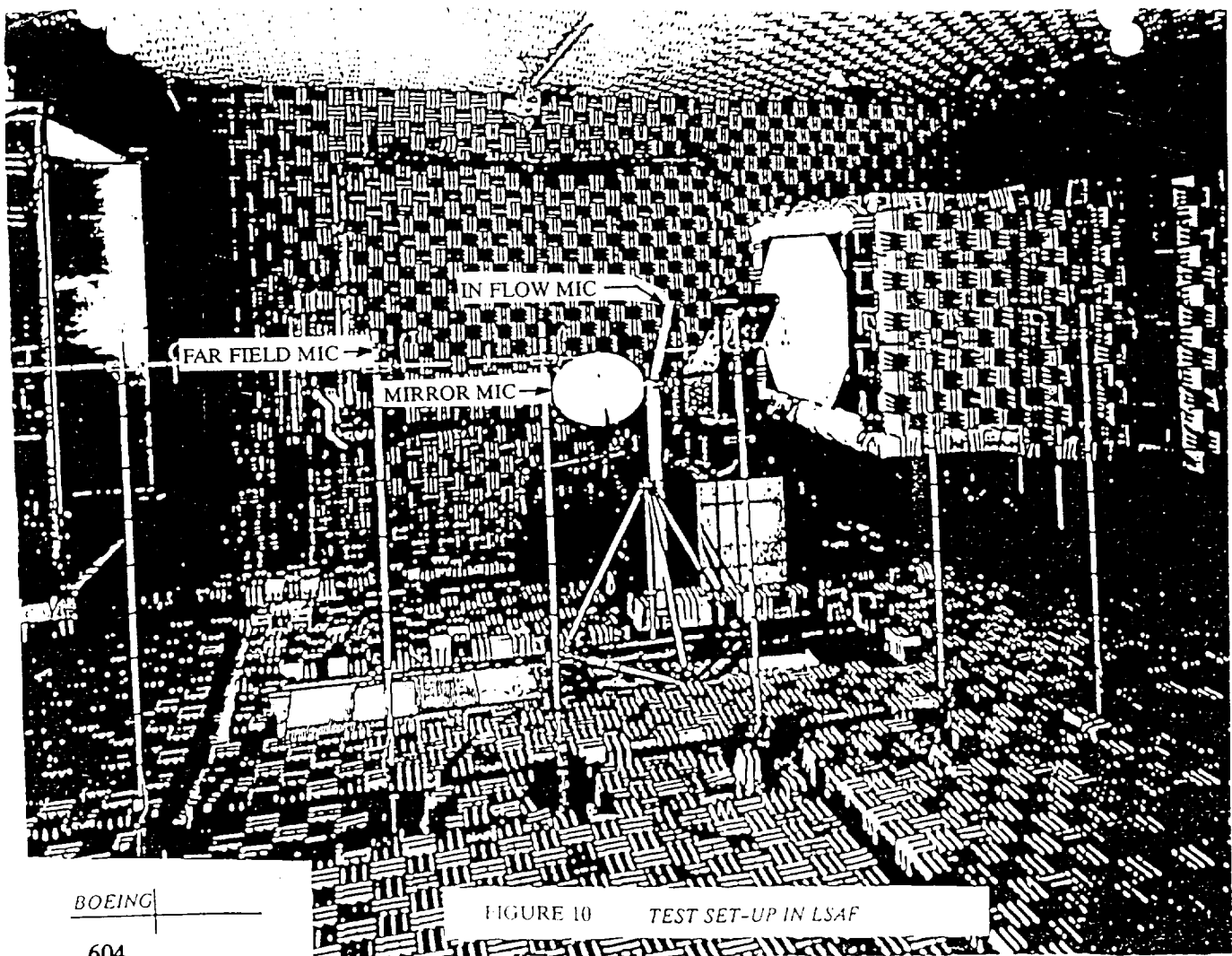
TEST TECHNOLOGY

- ◆ NOISE SOURCE LOCATION TECHNIQUES
- ◆ FLOW PARAMETER MEASUREMENT TECHNIQUES
- ◆ TECHNIQUES FOR CROSS-CORRELATION OF NOISE
WITH FLOW PARAMETERS
- ◆ FLOW VISUALIZATION TECHNIQUES

FIGURE 9

NOZZLE TEST IN LSAF

A nozzle test in progress in the Low Speed Aeroacoustic Facility (LSAF) wind tunnel at Boeing. The 9' X 12' free jet nozzle is shown as well as microphone locations. The translating elliptic mirror microphone is used to determine the noise source location. Far field noise measurements are made at 20 ft. sideline distance with fixed microphones out of the tunnel flow and within the flow with translating microphones at 4.7 ft.



SCHLIEREN PICTURES OF NACA NOZZLE

Flow visualization pictures taken by Jack Seiner's group from NASA Langley are shown. These pictures of the NACA nozzle test show the effect of translating the outer shroud length on shock cell strength. As the shroud was translated the expansion ratio (A/A^*) was changing.

SCHLIEREN RECORDS FOR CONFIGURATIONS 2.3 AND 2.1

(NPR=3.5, $M_T=0.23$, TTPA=1000°F, WBP ON)

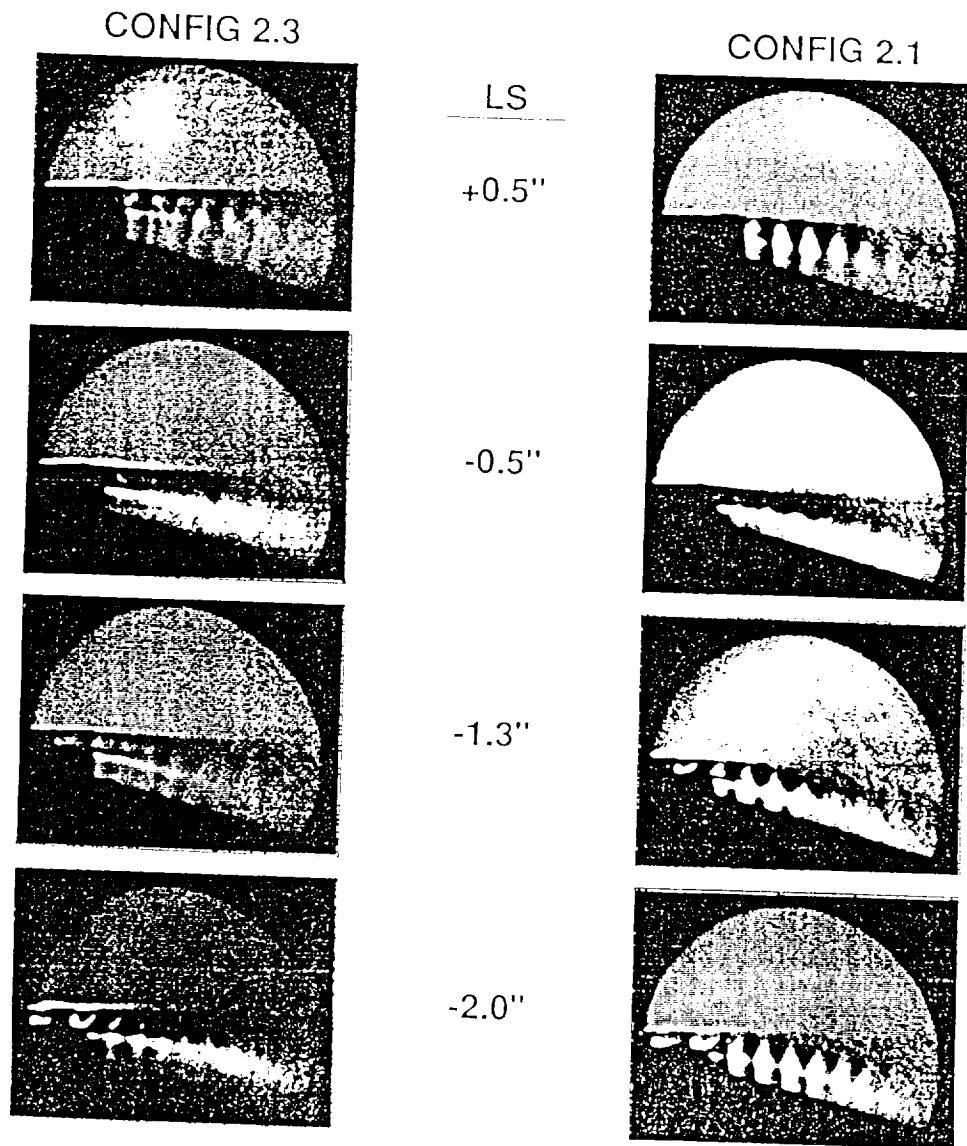


FIGURE 11

CONCLUSIONS

- * AN HSCT WILL REQUIRE NOISE CONTROL OF SEVERAL NOISE SOURCES, IN PARTICULAR JET NOISE, TO GET AIRPORT COMMUNITY ACCEPTANCE
- * ENGINE EXHAUST NOZZLE TECHNOLOGY DEVELOPMENT IS NEEDED TO ESTABLISH THE PENALTIES FOR 20 EPNDB SUPPRESSION SO THAT ENGINE CYCLE AND AIRPLANE TRADE STUDIES CAN BE MADE
- * IMPROVEMENTS IN JET NOISE TEST TECHNOLOGY AND PREDICTION TECHNOLOGY WOULD GREATLY ENHANCE THE NOZZLE DEVELOPMENT EFFORT